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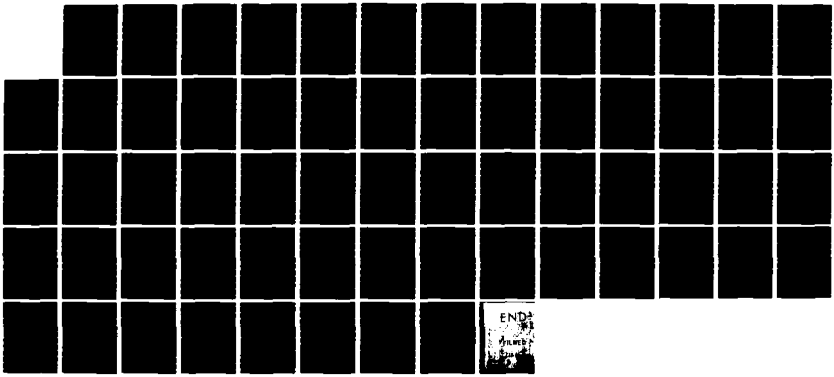

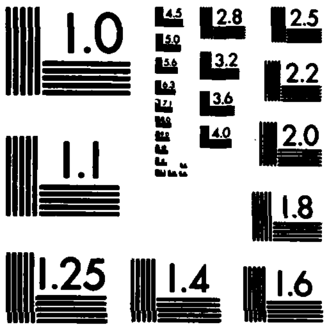

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DEMAND FORECASTING AND REVENUE REQUIREMENTS,
WITH IMPLICATIONS FOR CONSIDERATION IN BRITISH COLUMBIA

Jan Paul Acton

May 1983

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PREFACE

Until recently Canadian electrical utilities have received little regulatory review on matters of setting their electrical rates when compared with their U.S. counterpart utilities. Provincial regulatory boards have generally reviewed matters such as capital construction programs and overall level of electrical rates, but have not undertaken a detailed review of costs, alternative rate structures, and interclass comparisons of rates and costs. This has started to change within the last few years, with major reviews undertaken in Ontario and British Columbia. Because these are often the first discussions on many of the topics, these early cases have assumed many characteristics of a "generic rate" case proceedings--where considerable discussion focuses on principles of ratemaking rather than the fine tuning of an existing rate structure and set of relationships among customer classes.

The British Columbia Hydro and Power Authority became subject to general regulatory jurisdiction for the first time in September 1980. Among other things, this meant that any changes in gas or electric rates must have the prior approval of the B.C. Utilities Commission. The first such application was filed in June 1981 and hearings took place between January and December, 1982. The Utilities Commission's decision was issued February 28, 1983.

This paper was filed as an exhibit on behalf of The Consumers' Association of Canada (B.C. Branch), The Federated Anti-Poverty Groups of B.C., The Sierra Club of Western Canada, and the B.C. Old Age Pensioners' Organization. It was subjected to cross-examination on

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October 29, 1982, during Phase I of the hearings. The Utilities Commission had designated Phase I for consideration of (i) demand, (ii) assets in service, (iii) revenue requirements excluding return, and (iv) financing and capital requirements. Phase II was scheduled to consider such matters as rate structures. The Utilities Commission undertook to issue a decision after each phase. Their 1982 hearings and the February 1983 decision applied to Phase I. Phase II has not begun, and may await the next general rate filing by B.C. Hydro.

This paper presents a general discussion of the elements of a rate structure and their relationship to the demand for electricity, a systematic review of some 50 empirical studies of the demand for electricity as a function of price and other factors by the three principal classes of customers, and a discussion of the notion of "revenue requirements." The paper should be of interest to utility regulators, rate specialists, and forecasters for its review of demand models and to academics concerned with the study of energy demand.

In preparing this paper I benefitted from useful discussion with R. J. Gathercole and Ms. L. Parsons, attorneys for the B.C. Public Interest Advocacy Centre, and the research assistance of Yilmaz Arguden.

PREPARED EVIDENCE OF JAN PAUL ACTON

Phase I Hearings, Revenue Requirement

Prepared on Behalf of The Consumers' Association of Canada (B.C. Branch), The Federated Anti-Poverty Groups of B.C., The Sierra Club of Western Canada, and the B.C. Old Age Pensioners' Organization.

Q1 Please state your name and address.

A1 My name is Jan Paul Acton. I reside at 364 21st Place, Santa Monica, CA 90402. I am employed as a Senior Economist at the Rand Corp., but I am appearing in these proceedings as an individual and not as a representative of the Rand Corp. My education and professional qualifications are set forth in Appendix A.[1]

Q2 What is the purpose of your testimony?

A2 To discuss the relative importance of prices in load forecasting, to present empirical evidence of magnitudes of price response that are most applicable to the deliberations in British Columbia, and to draw implications for rate determination in B.C. Hydro.

Q3 Please outline your prepared testimony in this phase of the hearing.

[1] Appendix A omitted from Rand reprint of this testimony.

A3 First, I will review briefly the important elements of rate structures used in this discussion.

Second, I will review empirical studies of the demand for electricity with particular emphasis on the role of prices. My review will include an emphasis on Canadian studies and non-Canadian studies that are especially relevant to a rate case in Canada.

Third, I will discuss some implications of these studies for revenue "requirements" and load forecasting in the B.C. Hydro system.

Q4 Are there important aspects of the discussion that are not covered in your present testimony?

A4 Yes. It is my understanding that this phase of the hearings is to focus, among other things, on load forecasting and on revenue requirements and that discussions of rate structures are to take place primarily in Phase II of the hearings. It is difficult to discuss the role of prices in load forecasting and determination of revenue requirement without some attention to the elements of the rates. Empirical evidence and common sense suggest that price sensitivities differ by different elements of the rates structure as well as overall rate level. For example, customers may be price sensitive in general, but may display virtually no response to a change in the monthly customer charge.

In my testimony, I will try to follow the Commission's guidelines by discussing in Phase I price elasticities with respect to overall expensiveness of electricity and concentrate on non-time of day rate structures. I will discuss in Phase II elasticities with respect to specific rate structures. I will also reserve my recommendations for modification of present rate structures--or introduction of new rate structures--for Phase II of the hearings.

I. Definition of the Major Elements of Rate Structures Used in this Discussion

Q5 What are the major elements of a rate structure?

A5 There are three major components of an electrical rate structure that are relevant to our discussion: (a) the customer charge, (b) the kw demand charge, and (c) the energy charge.

a. CUSTOMER CHARGE is a fixed charge (usually monthly or bi-monthly) that the customer must pay, regardless of the amount of consumption in the time period, in order to receive electrical service. Sometimes this amount is recovered from the customer through a minimum bill per time period.

b. kw DEMAND CHARGE applies to the maximum rate at which electricity is consumed in a very brief time period--measured in kilowatts (kw). On some meters, the charge is

applied to the maximum instantaneous amount; with other meters, it is applied to the maximum average demand over a period of 15 or 30 or 60 minutes.

c. ENERGY CHARGE applies to the total amount of energy consumed--measured in kilowatt hours (kwh).

Q6 Are there other important definitions that underly the analysis of non-time of day rates?

A6 Yes, the most important is the use of block rate structures. These may be applied to either energy or kw demand charges. In a block rate structure for energy charges, the first so many kwh are priced at one level, the next so many kwh are priced at a different level, and so forth for as many blocks as the rate authority authorizes. For example, in a declining block rate structure the first 150 kwh per month might be priced at 5 cents/kwh; the next 250 kwh per month might be priced at 4 cents/kwh, and remaining kwh might all be priced at 3 cents/kwh in that month. An increasing block rate structure would be defined analogously with prices rising in steps as monthly consumption increases.

Block rate structures are found in some kw demand charges as well. They may operate directly on the price charged per kw of maximum demand per billing period or they may work indirectly through the energy charge. For example, a block extender rate has a variable price that is added to the energy charge and is expressed in cents per kwh. In

one specific example, the charge added to the energy charge might be 1 cent per kwh for the first 150 kwh per kw of maximum demand per month; 0.8 cents per kwh for the next 450 kwh per kw of maximum demand per month; and 0.6 cents per kwh for the remaining kwh per kw of maximum demand per month.

The point of the definitions is that empirical studies often distinguish some or all of these components in their definition of "price" and then proceed to use one or more component in their empirical analysis. Sometimes the results differ importantly depending upon the components used in defining "the price." Furthermore, if empirically *important differences are found, then forecasts of future* levels of demand should take account of what elements of the rate structure are being varied.

II. Review and Discussion of the Demand for Electricity, With Emphasis on Electricity Prices

A. Major Issues in Empirical Studies of Electricity Demand

Q7 What are the principal dimensions in which demand studies vary that are important to these deliberations?

A7 In my opinion, if the primary use is for load forecasting under different assumptions about price and related factors, then the important differences involve

-- the selection of the price variables used in analysis,

-- the choice of unit of observation--whether aggregated over groups of customers or whether the individual customer serves as the unit of observation,

-- the choice of functional[2] form employed for estimation,

-- whether the studies measure short or long run response,

-- the degree to which the study adequately accounts for other factors that may influence demand, and

-- the applicability of the findings estimated in one geographic area to the conditions of another geographic territory.

The first four factors are most important to assessing price-related response. The latter two factors are most important in predicting the level of use in a given utility service territory, taking account of non-price factors. When the primary application of a demand study is to help assess the effects of price changes, then the first four items are the most important--along with an assessment of whether or not the treatment of the non-price variables does or does not cause a bias in the price related effects.

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[2]The functional form refers to the mathematical representation of the estimating equations--for example, variables expressed in natural units, in their logarithms, in quadratic form, and so forth.

Q7 Please explain the difference between average price and marginal price as used in demand studies.

A7 "MARGINAL PRICE" refers to the per unit price of a small increment (or decrement) in consumption; it is the change in the customer's bill that results from small changes in level of use, divided by the amount of change in usage.

"AVERAGE PRICE" is the average of all prices the customer faces. It is usually calculated as the total bill divided by total consumption.

Q8 Could you give a simple example of the difference?

A8 Consider a customer who pays $2.00 per month in customer charge and 1 cent per kwh for energy. If he consumes 200 kwh per month, then his bill is $4.00. In this case, the $2.00 customer charge is the inframarginal charge and the 1 cent/kwh is the marginal (or incremental) price. If the consumer's use doubles to 400 kwh, then the bill does not double; rather, it increases to $6.00. Thus the marginal price is the important determinant of price effects over this range of adjustment.

Note that when the customer was consuming 200 kwh, his average price was 2 cents/kwh; when he was consuming 400 kwh, the average price was 1.5 cents/kwh. Looking at average price alone would suggest that his price was declining, when it fact the per unit price associated with additional consumption was constant.

In general, when a declining block rate structure is in effect (eg, 5 cents/kwh for the first 150 kwh/month; 4 cents/kwh for the next 250 kwh/month; and so on), the marginal price is the energy charge associated with the block (or level of use) the customer currently faces. For example, if the customer is consuming between 151 and 400 kwh, then the marginal price is 4 cents. The higher energy charge associated with the first 150 kwh (as well as any customer charge) is the inframarginal price in this case.

Q9 But many customers do not seem to know the details of their electrical rate structure. Is it not stretching things to say customers respond to their marginal price rather than average price?

A9 I do not think so. Customers certainly are affected by their total bill; after all that is what they have to pay at the end of each month. But when it comes to the economic impact of changes in consumption, marginal prices are more important. In the first place, many customers are quite well informed about electricity charges. In the instance of large commercial and industrial customers, they may have a full-time person whose responsibility it is to economize on energy use and that person will pay close attention to the details of electricity rates. Similarly, a number of residential customers have looked closely at their rates and are informed about the effects

of marginal prices. Secondly, and more pragmatically, through time, customers gain a feel for the effect on their bills when their consumption varies, for example from summer to winter or during holiday periods. When consumption doubles, they realize that bills do not always change by the same percentage as usage. Correspondingly, when households conserve electricity by some amount (say 20 percent), their bills do not fall proportionately.

Q10 What is the importance of distinguishing marginal from average price?

A10 It is important for statistical analysis and interpretation and it is important for forecasting. Consider the situation presented in the answer A8 above, when 200 kwh led to a bill of $4.00 and 400 kwh led to a bill of $6.00. If two customers were observed at these consumption levels in a statistical demand study, then using average price (rather than marginal price) would lead one to conclude that a fall in average price from 2 cents/kwh to 1.5 cents/kwh would lead to a doubling of electricity consumption. In fact, the price was identical for the two customers and the inference of a price-induced change would be spurious. Other factors are causing the differences in consumption. If the analyst were to use marginal price instead of average, the false inference would not be drawn.

Q11 What is the problem with using average price in statistical or econometric analysis?

A11 Primarily, it leads to bias in the estimated price effects, which can lead to erroneous forecasts. This bias is particularly important under a block rate structure or a rate that has a significant customer charge in relation to other charges (for at least a fraction of customers in the statistical analysis).

Under a declining block rate schedule, the average price per kwh approaches the marginal price as the quantity consumed increases. For example, using the price structure set out in answer A8 above, at 200 kwh, average price is 2 cents/kwh and marginal is 1 cent/kwh; at 400 kwh, average price is 1.5 cent/kwh and marginal is 1 cent; at 600 kwh, average price is 1.33 cent/kwh and marginal is 1 cent; and so forth. Thus the distortion between marginal and average price is not uniform, and under many important circumstances it will cause the apparent (estimated) demand curve to depart from the true demand curve.

A second bias is introduced when the average price is measured by revenue per kilowatt hour sold. Even when marginal prices are identical for customers drawn from a cross-section of utilities, differences in either the customer charges or inframarginal charge of the rate

schedules will cause the average price to vary, which can lead to erroneous estimates of price effects.

Third, use of an average per-unit revenue measure introduces a classic errors-in-variables problem by including total consumption in the equation as both the dependent variable and the divisor of one of the independent variables. This will bias the estimated price coefficient away from zero.

Finally, as illustrated in answer A10 above, if the average price is used in the estimation equation, then differences in consumption between consumers in the same rate block that are due to unmeasured non-price factors, such as weather or appliance stocks, will often be falsely ascribed to a price effect. This, too, will bias the estimated price coefficient away from zero.

Q12 Is this average price-marginal price distinction important for the conditions in British Columbia?

A12 Yes, for two reasons. First, in some instances, forecasts for British Columbia will be based in whole or part on analysis from other service territories where the distinction between average and marginal price is important. Second, empirical studies conducted exclusively with B.C. data must still distinguish average from marginal price. In the B.C. Hydro rates for each of the principal classes of service (bulk, general,

residential) there are declining block rate structures (and sometimes increasing block features as well). Therefore, both historic studies in British Columbia and forecasting future demands should take that fact into account.

Q13 What is the major consideration in studies using aggregated as opposed to disaggregated data?

A13 The major problem with using aggregated data for empirical analysis (e.g., all residential customers in a given utility or province) is that it leads to averaging over customers who often differ quite importantly in their individual characteristics that account for electricity use. This may mean averaging together households with important differences in appliances (for example, those with different type of space heating) or averaging across industrial customers with important differences in their equipment or production process. A particular example of the problem caused by this type of averaging is that aggregate data almost always force the analyst to use some form of average--rather than marginal--price, with the attendant problems of bias discussed immediately above.

Q14 How are you using the terms "short run" and "long run" in this discussion?

A14 "SHORT RUN" is defined as the period of time over which the customer makes no significant changes in capital stocks. For residential customers, this means that

appliances, housing characteristics (number of rooms, insulation, etc.), location, and the like remain fixed. For industrial or commercial customers, it means that equipment is not changed, building characteristics remain the same, and that the firm does not relocate. "LONG RUN" is defined as the period of time long enough to permit customers to make major changes in capital equipment, building characteristics, and location if they choose to do so.

Pragmatically, the short run would apply to periods of several months up through a few years for most customers. The long run would encompass the period five or more years after a change in price or other explanatory variable.

Q15 How is the term elasticity defined, and why is it used by economists in discussions of demand?

A15 "ELASTICITY" is defined as the percentage change in consumption divided by a given percentage change in the value of an explanatory variable. The most commonly used measures of elasticity are price elasticity of demand and income elasticity of demand--although in principle, elasticity could refer to anything (for example, the temperature elasticity of demand, to indicate the percentage change in use with a given percentage change in temperature). In the specific case of electricity, the price elasticity of demand for electric energy would be the percentage change in (say) monthly electricity use

divided by the percentage change in price.

Economists often use elasticity to summarize the measure of price responsiveness (or income responsiveness, etc.) because it does not depend on the units in which consumption and price are measured. Since both values are expressed in percentages, then consumption can be measured in kilowatt-hours or megawatt hours or joules of energy and the same answer results. Similarly, price may be expressed in dollars or cents or British pounds without loss. This is particularly useful when a regulator or analyst is considering the applicability of a demand study from one area to another service territory; as long as the consumer behaviour under consideration is believed to be applicable to present circumstances, then it does not matter if the original demand study were conducted using different units of measure than the present application calls for.

B. Review of Residential Studies of Demand

Q16 What studies did you review in preparing this testimony?

A16 I reviewed approximately 50 studies. They contain a variety of sources of data, level of aggregation, types of models employed, and so forth. The studies are listed in the references at the end of my testimony. I also reviewed the surveys prepared by Taylcr, Anderson, Nemetz

et al, and Denny, Fuss, and Waverman. Details of my review are contained in Appendix B. The major characterstics of studies I reviewed are summarized on pages B1-B3. Residential sector price and income elasticities are reported on pages B4-B7. Long run appliance saturation elasticities are reported on page B8. Commercial sector price and income elasticities are reported on pages B9-B10, and industrial sector price and output elasticities are reported on pages B11-B13.

A wide range of findings are reported, although findings are much more comparable when disaggregated studies are used and when comparable definitions of price are used. Based on my review of this literature, I would suggest the following range of values that are likely to encompass the true value of price elasticity applicable to the B.C. Hydro system in the short-run and in the long-run. These are necessarily judgmental statements on my part, but I think many other analysts would come to comparable conclusions after reviewing a similar set of studies. The range of values is intended to be wide enough to include the true value of price elasticity with a probability of 80 percent. That is, if one takes the range of values I suggest, then the actual elasticities in any particular instance would be encompassed by this "confidence band" 80 percent of the time.

TABLE 1
ACTON'S ESTIMATES OF RESIDENTIAL PRICE ELASTICITIES OF DEMAND FOR ALL HOUSEHOLDS

SHORT RUN			LONG RUN		
low	medium	high	low	medium	high
-0.12	-0.20	-0.35	-0.60	-0.90	-1.20

Q17 Are there other studies that survey price elasticity of demand from several empirical investigations?

A17 Lester Taylor reports the results of a survey published in the <u>Bell Journal of Economics</u>, Spring 1975 in which he reviews studies through the early 1970s. I am only aware of one other study that presents a similar explicit review and tabulation of probable elasticity values--having reviewed recent studies. It is the paper by Kent Anderson of NERA entitled "A REVIEW OF STUDIES OF THE DEMAND FOR ELECTRICITY," September 20, 1981 prepared for B.C. Hydro and entered as Exhibit 32 in the Site C hearing. I reviewed Anderson's study before preparing my testimony and have followed a number of his classification conventions to facilitate comparisons.

The chief differences between Anderson's method of review and my own are: (1) Anderson reviewed a number of older studies whereas I concentrated on studies published since 1975; in some cases, I have included recent studies that were not available at the time Anderson prepared his

review. (2) I have deliberately included a number of Canadian studies not in Anderson's review because I think they are especially important in these deliberations. Somewhat over one-third of the studies in my review are specifically Canadian studies.

Anderson's findings and my own are generally quite consistent, although my estimates tend to be a bit less elastic (closer to zero). He describes his lower and upper values as a range such that the odds are roughly 4:1 that the true elasticity lies within the limits. This is the same confidence band as the 80 percent range I am using.

TABLE 2

ANDERSON'S ESTIMATES OF RESIDENTIAL PRICE ELASTICITY OF DEMAND

SHORT RUN		LONG RUN	
lower=-0.15	upper=-0.30	lower=-0.70	upper=-1.50

Q18 How does price elasticity vary with level of use among residential customers?

A18 There are relatively few studies of this effect directly, although the evidence suggests that price elasticity increases with level of consumption. That is, the <u>proportional price response</u> increases with level of use--on top of the fact that the <u>absolute</u> response is greater because the amount of consumption is greater. Among other

things, this increasing price elasticity of demand is implied by studies which allow for different elasticities that are due to such characteristics as appliance holdings.

In one such study (Acton, Mitchell, Sohlberg), the researchers found that differences in appliance holdings affect both the overall level of use and the price elasticity of demand. These elasticities should be viewed as reflecting short-run behavior, since they are based on a particular stock of appliances. They are calculated as follows:

TABLE 3
RESIDENTIAL PRICE ELASTICITY ESTIMATES BY LEVEL OF USE

0-150kwh/mo.	151-400kwh/mo.	401-1000kwh/mo.	1001+ kwh/mo
-0.25	-0.35	-0.44	-0.54

The elasticities are calculated for assumed appliance holdings that are, respectively, one-half standard deviation below the mean appliance holding, at the mean, one-half standard deviation above the mean, and one standard deviation above the mean. These appliance holdings apply approximately to the range of monthly consumption indicated.

Q19 What is the effect of weather on electricity demand? In particular, how does it effect price responsiveness?

A19 In general, weather plays a very important role in the level of electricity use. More extreme temperatures--both hot and cold--increase use considerably. There is some disagreement whether the effect is linear in degree-days (or degree-hours) of temperature variation, but the effect is clear and statistically significant whenever analysts have examined it.

There has been considerably less attention given to the question of the effects of weather on price sensitivity, but when it has been analyzed, researchers have found that--if anything--price responsiveness increases with more extremely hot weather. Price responsiveness does not seem to change as the weather gets colder. This may be that--for a given increase in price--households are more likely to turn off air conditioners when they leave a house than they are to turn down (or off) electric heating. See, for example, Lillard and Acton's study of seasonal price responsiveness under a variety of seasonal and non-seasonal electricity rates.

Q20 What is the effect of income as reported in these studies?

A20 The effect of income is largely reflected through the purchase of appliances. All other things the same, higher income households own more electricity-using appliances and they tend to live in larger houses. Consequently, the effect of income is mainly to increase usage in the long run. When short-run demand models are estimated, and when

the analyst includes appliance holdings as explicit explanatory variables, then the short-run income elasticity of demand for electricity is found to be very small and/or not statistically significantly different from zero.

Q21 How do studies that focus especially on demand in Canada compare with the studies reviewed?

A21 Nine of the 34 residential studies that I reviewed use Canadian data. These specific studies of residential electricity demand in Canada produce findings consistent with the finding just summarized.

Summary of Residential Demand Studies

Q21 Please summarize your findings for residential customers.

A21 The overwhelming conclusion of these studies is that the level of price affects the quantity of electricity demanded in both the short-run and in the long-run. Although the magnitude of price elasticity may vary with the data, price used, and other factors, the price effects are statistically significantly different from zero by conventional standards of statistical inference. These empirical studies virtually rule out the possibility that price and quantity are unrelated.

In general, price elasticity is found to increase (in

absolute value) with:

-- greater holding of appliances,

-- higher income levels,

-- hotter weather (but not in colder weather; elasticities seem to remain stable as temperature falls successively below 65 F), and

-- price elasticities are greater (in absolute value) in the long-run than in the short-run.

C. Review of Commercial Studies of Demand

Q22 What are the principal findings of studies of commercial demand for electricity?

A22 There are relatively fewer studies of commercial demand than for residential demand. This may reflect greater ease of obtaining data and modelling household response than commercial response, and it may reflect a greater concern for policy impacts in the residential sector. Most studies of commercial demand group all commercial customers into the same unit of analysis. Consequently, both small and large retail stores, small and large grocery stores, small and large office buildings, customers in new and older structures (with widely different insulation and weather control equipment), etc., are all grouped together--usually with no distinction or allowance for these differences. Despite these aggregations and lack of explanatory variables, the

price-related findings are comparable to those reported for residential user. In my judgment, the following range of values probably encompass the true price elasticity of demand in the commercial sector, with probability 80 percent.

TABLE 4
ACTON'S ESTIMATED OF PRICE ELASTICITY OF DEMAND AMONG COMMERCIAL CUSTOMERS

SHORT RUN			LONG RUN		
low	med	high	low	med	high
-0.10	-0.20	-0.35	-0.40	-0.80	-1.00

Q23 What did Anderson report in his survey of commercial customers?

A23 Anderson performed a similar study that reviewed many of the same studies and provides very similar estimates.

TABLE 5
ANDERSON'S ESTIMATES OF PRICE ELASTICITY OF COMMERCIAL CUSTOMERS

SHORT RUN		LONG RUN	
lower=-0.10	upper=-0.30	lower=-0.40	upper=-1.00

Q24 How do Canadian studies compare?

A24 Three of the eight commercial studies I reviewed use Canadian data. These Canadian studies are consistent for this class of customers. Little attention has been given to differences in price elasticity under different weather

conditions in this class of customers.

Q25 Please summarize your findings for commercial customers.

A25 -- The quantity of electricity use is related statistically to the price of electricity,

-- The magnitudes of response are similar to those reported for residential users, although the studies generally do not control well for non-price factors, and

-- Long-run price elasticities are greater (in absolute value) than are short-run elasticities.

D. Review of Industrial Studies of Demand

Q26 What did your review of industrial studies reveal?

A26 There are a somewhat greater number of studies of industrial demand than for commercial customers, but fewer than for residential customers. Generally the analysts used fairly aggregated data. They often provide separate estimates for principal SIC classifications. Most attention has been given to demand for electricity by manufacturing customers; relatively little systematic attention has been given to demand by non-manufacturing customers or to agricultural, utility, or governmental customer classes.

There is considerable variability in the measured price elasticity of demand for electricity within the

manufacturing sector. The least price-responsive industrial groupings have considerably smaller (less elastic) price effects than either commercial or residential customers. The most price-responsive industrial groupings have price elasticities of demand for electricity that may be double that of residential or commercial users. Furthermore, there are important differences in the speed with which industrial customers appear to adjust to changes in electricity prices, leading to important differences in the relationship between short- and long-run price elasticities in this class of customers.

For example Anderson found the following ranges of values in his review of industrial demand studies.

TABLE 6
ANDERSON'S ESTIMATES OF PRICE ELASTICITY OF DEMAND AMONG INDUSTRIAL CUSTOMERS

	SHORT RUN		LONG RUN	
	Lower	Upper	Lower	Upper
MANUFACTURING	-0.20	-0.40	-0.70	-1.30
Lumber & Wood Pdts	-0.40	-0.70	-0.70	-1.10
Pulp & Paper	-0.25	-0.35	-0.70	-1.60
Chlorine	-0.20	-0.45	-0.80	-1.60
Petroleum Refining	-0.20	-0.30	-0.20	-0.90
Cement	-0.10	-0.30	-0.50	-1.00
Primary Metals	-0.15	-0.25	-0.90	-2.00
Other Mfg	-0.20	-0.30	-0.70	-1.10
MINING	-0.10	-0.30	-0.40	-1.00

For purposes of my analysis, I feel that Anderson's lower and upper values for all manufacturing are suitable guides to the 80 percent confidence bound.

TABLE 7
ACTON'S ESTIMATES OF PRICE ELASTICITY OF DEMAND AMONG INDUSTRIAL CUSTOMERS

SHORT RUN			LONG RUN		
low	med	high	low	med	high
-0.20	-0.30	-0.40	-0.70	-1.00	-1.30

Q27 Why do some industries seem to have relatively low elasticities in the short-run in combination with relatively large elasticities in the long run?

A27 I think the correct interpretation is that some industries seem to have relatively little flexibility in their production process in the short-run, but are capable of significant adjustments in plant configuration in the long run, when capital equipment--including perhaps cogeneration capability--can be constructed with the price of electricity taken into account. For example, pulp and paper, chlorine, and primary metals have slightly below-average price elasticities in the short-run, but above-average elasticities in the long-run. This implies that their demands are heavily determined in the short-run by factors other than price and that there is little possibility of substituting non-electricity inputs in the

short-run when electricity prices rise. In contrast, in the long run, when plant and equipment can be varied, there appears to be substantial possibility for substituting non-electricity inputs or making other adjustments that lead to a significant long-run price elasticity of demand.

Q28 How do Canadian studies of industrial electricity use compare with these general findings?

A28 Seven of the 13 studies I reviewed use Canadian data exclusively or Canadian data in combinations with other country's data. The results are quite consistent across countries.

Waverman et al specifically examined this question and found that other North American empirical studies were highly consistent with their own findings using Canadian manufacturing data estimated over comparable SIC code disaggregations. Among other things, this suggests that manufacturing processes are reasonably international in character and somewhat less affected by variations in "local habits" or differences in climate than may be the case for residential users.

Industrial Response to Interruptible Rates

Q29 Are there other important aspects of customer demand that are especially relevant to this phase of the hearings?

A29 Yes. In a few instances, industrial customers have faced an interruptible electricity rate which has resulted in significant reductions in electricity use on an occasional basis.

In England and Wales, the Load Management Warning (LMW) tariff provides a very strong price incentive for holding down demand during a few hours of the year. I have studied this program first hand and have talked with both utility people and large industrial customers who face these rates.

Under the load management tariff, firms agree in advance to pay a charge for their average demand during the load management warning periods and a charge for their maximum demand in any LMW period during the year. In recent years, the charge was about L10/kw of average demand and L3/kw for maximum demand during LMW periods. In recent years, only a few hours of load management have been declared (and in no case have the number of hours exceeded 20 per year compared with the 50 allowed by the tariff).

Approximately 110 firms have elected to be under the terms of the Load Management Warning tariff and they reduce their collective demand significantly in declared load management periods. On one occasion during the mid 1970s, the Electricity Council analysts were able to observe the effects of a load management warning while conducting a

routine load study, and they observed an average reduction of 40 percent from normal winter weekday demand by the 110 firms on the LMW tariff. See Mitchell, Manning, and Acton (1978, p. 113). This accounts to about 1300 megawatts of reduction in all, which is about 11 percent of class load and 3 of the entire system winter peak load in England and Wales.

In the absence of a detailed load study conducted during the load management period, we must approximate indirectly the degree of reduction that occurs in response to a LMW tariff.

Over all, the firms in this group total almost 570 MW of demand during load management period as compared with a (non-coincident) maximum demand of 2,733 MW throughout the year. That is, demand during LMW periods averages 22 percent of non-coincident annual maximum demands for these firms. For some firms, the average of 22 percent represents an over-estimate of response because winter demands are below other seasons of the year; for other firms, the 22 percent average is the approximately correct measure because the firms peak in the winter during conditions that might result in a LMW being called.

We also performed regression analysis on load management response, accounting for differences by major industrial groups. The regressions indicate that the mean level of

demand during Load Management Warnings is about 40 percent of the maximum annual demand for firms lacking self-generation and about 20 percent for firms with self generation. The steel, cement, and miscellaneous electric heating industries each average about 20 percent of maximum demand during Load Management Warning periods. The overall response in this group is greater than this summary indicates. The miscellaneous electric heating load category excludes small electric arc furnaces--which are uniformly at zero consumption during LMW periods. Most other industries are not, on average, statistically significantly different from the average of all these LMW firms.

E. Applicability of Study Findings to British Columbia

Q30 How applicable are these findings to the situation of British Columbia?

A30 Clearly the surveys of empirical studies suggest that it is important to take into account the circumstances in a particular area when estimating demand and making forecasts. But the empirical studies also suggest that there are important behavioral commonalities across customers and across different utility systems. This is especially true for studies of industrial demand for electricity, where the underlying production processes are often quite similar from on area to another. In addition,

there are important similarities in the behavior of commercial and residential customers as well, particularly when disaggregated data are used for estimation.

Q31 What is the relationship between the customer groupings you have just reviewed--industrial, commercial, and residential--and the types of service provided in the B.C. Hydro area?

A31 The most important designation of service level used in the B.C. Hydro system for both costing and ratemaking purposes is defined by voltage level. For simplicity, I will refer to the distinction as high voltage, medium voltage, and low voltage to correspond to the three principle voltage levels at which customers receive service. High voltage refers to the level at which bulk service customers receive service; virtually all of these customers are industrial users and correspond well to the industrial customers reviewed above. Medium voltage service encompasses both commercial customers in the B.C. Hydro system as well as many manufacturing customers--and perhaps some master-metered apartment buildings. For practical purposes, medium voltage service can be viewed as a composite of commercial and industrial users. Low voltage service is supplied to the smaller commercial customers and almost all residential users. In the B.C. Hydro system, the findings reported for residential customers would be most applicable for the majority of low

voltage customers.

F. Conclusions of Empirical Analysis

Q32 Please summarize the principal findings that you consider relevant to these deliberations.

A32 My principal findings for demand studies in general are:

1 First, price is important in estimating and forecasting electricity demand. When price is properly accounted for, virtually every empirical study finds that price effects are statistically significant. The likelihood that this price-quantity relationship is due to chance is virtually zero.

2 It is important to distinguish short-run and long-run response for each class of customer.

3 In absolute value, own-price elasticities are smaller in the short run than in the long run.

4 Long-run price elasticities are generally more uncertain than are short-run price elasticities.

5 In the short run, the level of demand depends primarily on:

-- marginal price of electricity,

-- appliance holdings, and

-- weather.

6 In the short run, demand depends relatively little on

-- income (which has its primary effect through appliance holdings) or

-- inframarginal charges in the rate structure.

7 In the long run, residential demand:

-- depends more importantly on the full rate structure,

-- may be influenced by customer charges as well as marginal charges ,

-- depends importantly on appliances or equipment, housing characteristics, and location.

-- Appliance choice (including rated capacity and efficiency), in turn, probably depends on the full rate structure and income.

8 For commercial and industrial customers, the customer charge and inframarginal charges may affect major locational decisions, production capacity, and decisions regarding the use of cogeneration or combined heat and power systems.

9 A lot more is known about elasticity of demand with respect to energy (kwh) charges than elasticity with respect to kw demand charges.

10 For empirical analysis, the use of average price versus marginal price can be summarized as follows:

-- In the short run, marginal price is clearly superior theoretically, econometrically, and on the basis of the statistical findings.

-- Because major capital investment decisions and locational decisions take account of the overall expensiveness of using electricity (and not just the

marginal price), it may be less important to distinguish marginal and average price in the long-run. Either price measure appears to work reasonably well and other factors are probably relatively more important in determining demand.

11 Seasonal differences in price responsiveness have not been studied as thoroughly as some other aspects of demand. Seasonal differences in demand appear to depend chiefly on temperature and appliance holdings--which in turn may affect both level of demand and price elasticity of demand. When seasonal price elasticities have been analyzed explicitly, price responsiveness is found to increase with

-- greater holdings of weather sensitive appliances and

-- more extreme weather when hot (but not when colder),

III. Implications of Demand Studies and Price Responsiveness for Revenue Requirements in B.C. Hydro

Q33 What are the primary factors that influence revenue "requirement" in B.C. Hydro's system?

A33 Although these are often referred to as revenue "requirements," we should be clear at the outset that these are expenditures, which vary with the amount and condition of supply, and whose magnitude depends on managerial efficiency, historically determined plant and equipment, administrative review by bodies such as this

Commission, and the level and composition of energy sales. There are a number of components of expenditure that can be usefully grouped into six categories:

1. Servicing Historic Financial Obligations. These are largely determined by historic decisions such as the issuing of long term indebtedness. Their magnitude is little affected by changes in consumption in the short-run. The amount of future financing obligations will be largely determined by the conditions of the financial markets, the amount of construction activity that is planned or undertaken, and the decisions regarding target levels of interest coverage or debt/equity ratios (see also points 4 and 5 below).

2. General administration and operation expense. The amount of this expenditure is a managerial decision, much of which is determined by historic staffing decisions and the number of customers to be served. This expenditure is certainly subject to managerial review and control for efficiency purposes, but it is relatively little affected by short-run changes in the level of energy use.

3. Running costs. These costs are most influenced by changes in the level of energy use in the system. They are often referred to as variable operating and maintenance costs and they include maintenance and repair, water rental rates, fuel costs, and the costs of purchased energy.

4. Planning and construction of new facilities. In a system such as B.C. Hydro, these can be a major cause of expenditure. Based on projections of future levels of demands, the utility plans and constructs generation, transmission, and distribution facilities. These facilities are capital intensive, long lived, and may require long lead times for planning and construction. Some combination of current revenue, retained earnings, and new financing usually covers these expenses.

5. The level of interest coverage or debt/equity ratio that the utility attempts to maintain. This target can exert considerable leverage on the amount of outstanding debt and the interest rates paid.

6. Offsetting these costs are export sales which serve to reduce the net expenditure, or "revenue requirement," of the utility system.

This is not intended to be a comprehensive discussion of the matter. Rather it is intended to suggest which categories of costs and expenditures are relatively pre-determined over a given time period and which are subject to variation. A rate structure is designed and rate levels are set to reflect these costs and to meet the financial obligations of the utility.

The important point is that unless customers are *perfectly price insensitive* (price elasticity is *zero*), the level

and structure of rates will affect the quantity of energy consumed in both the short run and the long run. Therefore, rates will affect the (a) operating costs, (b) the desirable amount and type of generating equipment, (c) the long-run construction costs, (d) the financing costs, and (e) the revenue of the utility.

As things currently stand, B.C. Hydro apparently does not systematically incorporate the quantitative feedback effect of rates on quantity demanded. This is a problem for at least three reasons. First, depending on the rate structure selected, this will result in either over-collection or revenue shortfalls. Second, by failing to account for price effects, the utility is likely to commit to an inappropriate amount and composition of new capital facilities (generation, transmission, and distribution equipment). Third, since price elasticities may vary importantly by customer group, ignoring price feedbacks on consumption may have a differential effect on different customer groups.

IV. Implications of Price Elasticities for for Future Load Growth and Revenue Requirement (or Rate Level)

Q34 What do these price elasticities imply for future load growth and revenue requirement in the B.C. Hydro system?

A34 In general, they mean that if electricity rates are expected to rise in real terms (i.e., adjusted for inflation) for one or more customer groups, then demand will be less than it would have been otherwise. This may mean that load growth still occurs--but at a slower rate--or it may mean an actual reduction in future usage. Conversely, if prices are expected to fall in real terms, then demand will be more than it would otherwise have been.

Q35 What rate level effects do you project for the B.C. Hydro system?

A35 It is impossible to project a specific impact in B.C. Hydro until the level of price increase and rate structure is known. There is a feedback between rates and load growth--leading to revised rates and thence to revised load forecasts. Furthermore, if capital plans are adjusted (which they should be), then rates and revenue targets should be adjusted again, setting up the sequence of feedbacks. This problem can and should be solved by the utility in making load forecasts and expansion plans.

In the absence of specific projected rate increases that have already taken account of these price-quantity feedbacks, I will take three levels of assumed real price increase and summarize the estimates on load changes for the short-run and the long-run for each of the three major customer classes. These estimates are based on the tables

of elasticities provided above. For illustrative purposes, I have selected real price increases of 5%, 10%, and 15%.

The short-run estimates apply to the period immediately after a price increase occurs. They reflect customer behavior before they have a chance to make significant changes in appliances, equipment, or location. The low and high values are intended to span the range of true response with probability 0.80.

TABLE 8
ESTIMATED SHORT-RUN LOAD CHANGES WITH THREE ASSUMED VALUES OF REAL PRICE INCREASES

	CHANGE IN CONSUMPTION (%)					
	RESIDENTIAL		COMMERCIAL		INDUSTRIAL	
REAL PRICE CHANGE	low	high	low	high	low	high
5%	-0.6	-1.8	-0.5	-1.8	-1.0	-2.0
10%	-1.2	-3.5	-1.0	-3.5	-2.0	-4.0
15%	-1.8	-5.3	-1.5	-5.3	-3.0	-6.0

The long run is defined as a period of time long enough after a price change for significant capital (and possibly locational) changes to take place if the customer desires it. I have selected 5 years for specificity and have assumed that at least 80% of the long-run price adjustments given above have occurred.

TABLE 9
ESTIMATED LONG-RUN LOAD CHANGES WITH THREE ASSUMED VALUES OF REAL PRICE INCREASES (5 YEARS)

	CHANGE IN CONSUMPTION (%)					
	RESIDENTIAL		COMMERCIAL		INDUSTRIAL	
REAL PRICE CHANGE	low	high	low	high	low	high
5%	-2.4	-4.8	-1.6	-4.0	-2.8	-5.2
10%	-4.8	-9.6	-3.2	-8.0	-5.6	-10.4
15%	-7.2	-14.4	-4.8	-12.0	-8.4	-15.5

V. Conclusion

1 An increase in price will serve to dampen load growth. All load forecasts should take account of price responsiveness as well as other factors. Failure to take account of price responsiveness in a period of rising prices will result in overestimating future demand for electricity and will generally lead to overinvestment in net generating equipment.

2 Increasing the interest coverage ratio (or reducing the debt/equity ratio) in B.C. Hydro will cause prices to rise over what they would otherwise have been. The amount by which rates are projected to rise due to the increased interest coverage target of 1.3 to 1 is enough to reduce load growth forecasts substantially over the next several years.

3 Any additional increase in rates (for example, to expand capacity) will have a dampening effect on load growth. This dampening in demand <u>should</u> be taken into account in producing a revised load forecast and associated plant construction program.

APPENDIX

Tables and References

SELECTED CHARACTERISTICS OF THE MODELS SURVEYED

Study	Consumer Sector Evaluated	Time Period	Structure: Equation Type	Structure: Equation Form	Fuel Prices Used
	(1)	(2)	(3)	(4)	(5)
Houthakker-Verleger-Sheehan (1974)	R	1960-1969	Electricity	log-linear	none
Baughman-Joskow (1975)	R	1969	Total Energy Energy split Appliance	exponential logit logit	natural gas, number 2 fuel oil
Halvorsen (1975)	R	1961-1969	Electricity	log-linear, exponential (price variable logged)	all types of residential gas
Wilder-Willenborg (1975)	R	1973	Electricity	mixed log-linear, exponential (price variable logged)	none
Hyndman-Mathewson (1975)	R	1958-1971	Energy split Electricity	linear	oil, natural gas
Battalio-Kagel-Winkler-Winett (1976)	R	1975	NA	NA	NA
Cohn-Hirst-Jackson (1977)	R	1951-1974	Electricity	log-linear	natural gas, fuel oil
Fuss-Hyndman-Waverman (1977)	R	1958-1971	Electricity	mixed log-linear, exponential	none
	C	1960-1971	Electricity	linear	Price variable expressed as a ratio of electricity to a substitute fuel: natural gas, coal or oil
	I	1961-1971	Total energy Energy split	translog	coal, liquified petroleum gas, fuel oil, natural gas, motor gasoline
McFadden-Puig-Kirshner (1977)	R	1975	Electricity Appliance	log-linear logit	none natural gas
Taylor-Blattenberger-Verleger (1977)	R	1956-1972	Electricity	log-linear	natural gas
	R	1961-1972	Appliance	log-linear for all appliances except linear for refrigerators	natural gas

SELECTED CHARACTERISTICS OF THE MODELS SURVEYED

Study	Consumer Sector Evaluated	Time Period	Structure: Equation Type	Structure: Equation Form	Fuel Prices Used
	(1)	(2)	(3)	(4)	(5)
Lyman (1978)	R C,I	1959-1968 1961-1968	Electricity	linear, log-linear, exponential and mixed log-linear, exponential	natural gas
Chern-Just-Holcomb-Nguyen (1978)	R,C,I	1955-1974	Electricity	mixed log-linear, exponential (price variable logged)	natural gas: R,C,I; number 2 fuel oil: R,C; number 6 fuel oil: I; coal: I
Yang (1978)	R	1962-1975	Electricity	log-log	natural gas
Parhizgari-Davis (1978)	R	1964-1974	Electricity	log-log	none
Denny-Fuss-Waverman (1979)	I	1962-1975	Energy split Electricity	mixed log-linear	4 different types of oil, coal, coke, natural gas
Houthakker (1979)	R	1964-1976	Electricity	log-log	natural gas
Walker (1979)	R	1972-1975	Electricity	log-log	none
Pindyck (1979)	R	1960-1974	Total Energy Energy split	translog	solid fuel, liquid fuel, gas
	I	1963-1973	Total Energy Energy split	translog	solid fuel, liquid fuel, gas
Spann-Beauvais (1979)	All	1960-1973	Electricity	mixed log-linear	number 6 fuel oil
Smith (1980)	R	1957-1972	Electricity	log-linear	natural gas
Chang-Chern (1980)	I	1959-1976	Electricity	double-logarithmic	oil, coal, natural gas
Sahi-Erdman (1980	R,C,I	1963-1974	Energy split	double-logarithmic	oil, natural gas
Berndt-May-Watkins (1980)	R,C,I	1961-1976	Energy split Electricity	linear, log-linear mixed log-linear	combined "other" energy
Nemetz-Hankey-Zethoff (1980) (Reviews other studies)	R	1958-1971	Electricity	double-logarithmic, exponential, non-linear	none, heating oil natural gas
Chern-Dick-Gallagher-Holcomb-Just-Nguyen (1980) (Obtained from Chern et al., 1982)	R,C,I	1955-1976	Electricity	dynamically specified logarithmic Koyck	number 2 fuel oil, natural gas for R & C number 6 fuel oil, coal, and natural gas for I
Acton-Mitchell-Sohlberg (1980)	R	1972-1974	Electricity	linear	natural gas

SELECTED CHARACTERISTICS OF THE MODELS SURVEYED

Study	Consumer Sector Evaluated	Period	Structure: Equation Type	Structure: Equation Form	Fuel Prices Used
	(1)	(2)	(3)	(4)	(5)
Hartman-Werth (1981)	R	1960-1975	Electricity	linear	none
Wills (1981)	R	1975	Electricity	linear	natural gas
Roth (1981)	R	1974-1977	Electricity	linear, log-log	natural gas
Common (1981)	R	1968-1978	Electricity	log-log	none
Besen-Kirby-Negri-Wetzel (1981)	R	1973,1975, 1976,1978-79	Electricity	linear	none
Cocke-Smith-Johnston-Howard (?)	R	1975-1979	Electricity	log-log	none
Betancourt (1981)	All	1972-1975	Electricity	mixed log-linear	none
Chung-Aigner (?)	C,I	1975-1979	Electricity	translog	none
Colombia-Pacific Resources Group, Ltd. (1981)	All	NA	Energy split	NA	NA
Dent-Kim-Chan-Pelipe-Flynn-Ioannov (1982)	I	1975-1980	Electricity	spline	fuel oil, natural gas
Archibald-Finifter-Moody (1982)	R	1975	Electricity	linear	none
McRae-Webster (1982)	I	1962-1976	Energy split	translog	natural gas, fuel oil, coal, motor gasoline, LPG
Chern-Just-Chang (1982)	R,C,I	1955-1976	Electricity	mixed log-linear	none
Helliwell-Margolic (1982)	All	1961-1980	Energy split	mixed log-linear	oil, gas
Lillard-Acton (1982)	R	1975-1977	Electricity	mixed log-linear	none

Note: NA indicates not available or not applicable.
R: Residential; C: Commercial; I: Industrial;
All: Non-differentiated total demand.

RESIDENTIAL SECTOR PRICE AND INCOME ELASTICITIES

Date	Study	Data: Type	Data: Time Period	Price Elasticity: Short-Run	Price Elasticity: Long-Run	Income Elasticity: Short-Run	Income Elasticity: Long-Run	Type of Price	Notes
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
May 1974	Houthakker-Verleger-Sheehan	CS-TS: USA, States	1960-1971	-0.03/-0.09	-0.45/-1.20	0.13/0.15	1.60/2.20	M	
Feb 1975	Halvorsen[1]	CS-TS: USA, States	1961-1969	---	-1.00/-1.21	---	0.47/0.54	M*	[1]Results for structural equations.
May 1975	Hyndman-Mathewson	CS-TS: 4 Canadian Provinces	1958-1971	---	-0.107	---	0.332	A	
Dec 1976	Battalio-Kagel-Winkler-Winett	NA	1975	0.0/-0.15[2]	---	---	---	NA	[2]Price changes are experimentally induced.
Jan 1977	Taylor-Blattenberger-Verleger[3]	CS-TS: USA, States	1956-1972 1956-1972	-0.07/-0.08 -0.16/-0.66	-0.81/-0.82 -0.46/-0.30	0.09/0.10 0.22/0.57	1.05/1.08 1.00/1.36	M	[3]First row of values, flow adjustment models. Second row, capital-stock models. Based on Anderson; not independently reviewed.
Mar 1977	Cohn-Hirst-Jackson	CS-TS: USA, States	1951-1974 1960-1974 1965-1974 1969-1974	-0.14 -0.20 -0.16 -0.14	-1.16 -0.89 -0.78 -0.47	0.02 0.10 0.06 0.16	0.16 0.46 0.43 0.56	A	
Aug 1977	McFadden-Puig-Kirshner	CS: USA, Households	1975	---	-0.66/-0.73	---	0.39	M	[4]Elasticity calculated for Ontario, 1971, not significant at .05 level.
1977	Fuss-Hyndman-Waverman	CS-TS: Canada, Provinces	1958-1971		-0.14[4]	(positive)[5]		M	[5]Statistically significant at better than 0.01.
July 1978	Yang	CS-TS: USA, States	1962-1975	-0.567		0.309		M	

RESIDENTIAL SECTOR PRICE AND INCOME ELASTICITIES

Date	Study	Data: Type	Data: Time Period	Price Elasticity: Short-Run	Price Elasticity: Long-Run	Income Elasticity: Short-Run	Income Elasticity: Long-Run	Type of Price	Notes
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Oct 1978	Chern-Just-Holcomb-Nguyen[6]	CS-TS: USA, States by census region	1955-1974	-0.33 -0.22 -0.35 -0.27 -0.31 -0.47 -0.57 -0.19 -0.08	-1.50 -0.60 -1.22 -0.73 -1.12 -0.95 -1.07 -0.43 -0.37	0.07 0.34 0.06 -0.01 0.21 0.30 0.27 0.45 0.01	0.32 0.91 0.19 -0.02 0.77 0.61 0.51 1.03 0.04	A	[6] First row of values, New England; second row, Mid Atlantic; third row, East North Central; fourth row, West North Central; fifth row, South Atlantic; sixth row, East South Central; seventh row, West South Central; eighth row, Mountain; ninth row, Pacific. Results are for third stage least squares (3SLS).
Dec 1978	Parhizgari-Davis	CS-TS: USA, States	1964-1974	-0.04[7] -0.15 -0.19	---	0.71	---	M	[7] Elasticities are for 3 marginal block prices.
1978	Lyman[8]	CS-TS: USA, Areas served by 67 utilities for 10 geographic regions	1959-1968	---	-1.02 -1.15 -0.13 -1.05 -0.82 -1.17 -1.13 -0.58 -1.36 -0.19	---	0.17 0.55 0.24 0.35 0.30 0.08 -2.07 -2.14 -0.54 0.11	A	[8] Elasticities are for the following regions: West Coast, Northwest, North Midwest, Midwest, Middle Atlantic, Southwest, North Texas, South Texas, South, Florida and Gulf. Calculated at sample means.
June 1979	Houthakker	CS-TS: USA, States	1964-1976	-0.111	-1.4	0.139	1.8	M	
1979	Walker	TS: A Texas community residents	1972-1975	-0.14	---	0.74	---	M	
1979	Pindyck[9]	CS: 9 OCED countries	1960-1974	---	-0.30/-0.39 -0.25/-0.30	---	1.00[10] 1.00[10]	A	[9] First row of values is for Canada; second for U.S. at 1965 and 1973 means. [10] Constrained ɔ unity by assumption.
1979	Spann-Beauvais	TS: A Virginia utility	1960-1973	-0.31[11]	-0.44[11]	0.64[11]	0.91[11]	M	[11] Peak demand elasticities.
1980	Acton-Mitchell-Sohlberg	CS-TS: Los Angeles County census tracts	1972-1974	-0.35	-0.70[12]	0.38	0.40[12]	M	[12] Excluding March-April 1974 billings in which DWP curtailment ordinance was in effect.

RESIDENTIAL SECTOR PRICE AND INCOME ELASTICITIES

Date	Study	Data: Type	Data: Time Period	Price Elasticity: Short-Run	Price Elasticity: Long-Run	Income Elasticity: Short-Run	Income Elasticity: Long-Run	Type of Price	Notes
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Apr 1980	Smith[13]	TS: 27 Investor-owned utilities	1957-1972	-0.11/-1.57		0.21/1.62		A	[13] The results are for 2SLS. The range indicates values across 27 utilities.
1980	Sahi-Erdmann	CS-TS: 7 Canadian regions	1963-1974	---	-0.988	---	---	A	
1980	Brendt-May-Watkins	TS: Alberta	1961-1976	-0.24	-0.6	0.37	0.95	A,M	
Apr 1980	Nemetz-Hankey-Zethoff	CS-TS: Canadian Atlantic Provinces	1958-1971	---	-0.29[14] -0.19[15]	---	---	A,M	[14] From Fuss-Waverman (1975) per household. [15] From Fuss-Hyndman-Waverman (1977) per household.
1980	Chern-Dick-Gallagher-Holcomb-Just-Nguyen	CS-TS: USA, States	1955-1976	-0.210[16] -0.218 -0.349 -0.254 -0.299 -0.355 -0.392 -0.139 -0.076	-1.154 -0.618 -1.091 -0.700 -1.079 -0.728 -0.907 -0.373 -0.402	---	---	NA	[16] Rows are for New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain and Pacific States, respectively.
Sep 1981	Lillard-Acton	CS-TS: Individual households Los Angeles	1975-1977	-0.0576		0.2[17]			[17] The principal long-run effects of income may act through housing value, appliances and pool ownership. Based on seasonal and non-time-of-day plans in the Los Angeles rate experiment.
May 1981	Hartman-Werth	CS-TS: USA, States	1960-1975	-0.19		0.9		M	
July 1981	Common	CS-TS: U.K.	1968-1978	-0.214	-0.212[18]	0.476	0.441[18]	A	[18] From a partial adjustment model which showed that .937 was the ratio of long-run to short-run elasticity.
1981	Roth	TS: A south-western utility, residents in U.S.	1974-1977	-0.11[19]				A,M	[19] The elasticity is for marginal price. Average price elasticity is +0.39.

RESIDENTIAL SECTOR PRICE AND INCOME ELASTICITIES

Date	Study	Data: Type	Data: Time Period	Price Elasticity: Short-Run	Price Elasticity: Long-Run	Income Elasticity: Short-Run	Income Elasticity: Long-Run	Type of Price	Notes
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Aug 1981	Besen-Kirby-Negri-Wetzel	CS: USA	1973, 1975, 1976, 1978-1979[20]	-0.40	-0.90	0.13	0.22	M	[20]4 different data sets are used. The results reported here are for the most recent years (i.e., 1978-79).
1981	Betancourt	CS-TS: 6 U.S. utilities in different census regions	1972-1975[21]	-0.17[22]	---	---	---	A	[21]He has also used 1972-1976 period but obtained unexpected signs on some elasticities. [22]This is a peak demand elasticity and reflects only conservation, <u>no</u> shifting.
Oct 1981	Wills	CS: Massachusetts districts	1975		-0.27			M	
Nov 1981	Colombia-Pacific Resources Group, Ltd.	Canada	NA	-0.47[23]				NA	[23]Peak demand elasticity.
	Cocke-Smith-Johnston-Howard	TS: California	1975-1979	-0.15	---	---	---	A	
Jan 1982	Helliwell-Margolic	CS-TS: 4 Canadian regions	1961-1980[24]	---	-0.53	---	---	F	[24]For some equations 1955-1980 data was used.
June 1982	Chern-Just-Chang	CS-TS: USA, States	1955-1976	-0.48[25] -0.39	---	0.15	---	A,M	[25]These elasticities refer to average and marginal price elasticities, respectively.
1982	Archibald-Finifter-Moody	CS: USA, States	1975	-0.39	---	0.11	---	M	

Note: A indicates average price.
M indicates marginal price.
M* indicates a theoretical model in which both average and marginal price elasticities are identical (price data was A or F).
F indicates a price for a fixed amount of electricity, either average or marginal price.
NA indicates not available or not applicable.
TS indicates time-series data.
CS indicates cross-sectional data.
CS-TS indicates pooled CS and TS data.
Elasticities between short- and long-run columns are ambiguously defined in the reference cited.

LONG-RUN APPLIANCE SATURATION PRICE ELASTICITIES

Date	Study	Data: Type	Data: Time Period	Long-Run Price Elasticities: Heater	Cooking Fuel	Clothes Dryers	Space Heating	Food Freezing	Air Conditioning: Room	Air Conditioning: Central	Dishwashing	Notes
Feb 1975	Baughman-Joskow	CS: USA, States	1969	-1.77	-0.78	-0.53	-2.08	NA	NA	NA	NA	
Jan 1977	Taylor-Blattenberger-Verleger[1]	CS-TS: USA, States	1960-1972	-0.26	-0.45	0.11	-0.87	-0.32	-0.42	-0.56	NA	[1] Based on Anderson's review. Not independently verified.
Aug 1977	McFadden-Puig-Kirshner	CS: Households	1975	-1.95	NA	NA	-2.95[2]	NA	-0.17[3]	NA	NA	[2] Value is for water and space heating. Elasticity is positive for space heating alone. [3] Not specified whether room, multiple room or central.

Note: NA indicates not available.
CS indicates cross-sectional data.
CS-TS indicates pooled cross-sectional and time-series data.
Elasticities are evaluated at sample mean

COMMERCIAL SECTOR PRICE AND OUTPUT ELASTICITIES

Date	Study	Data: Type	Data: Time Period	Price Elasticity: Short-Run	Price Elasticity: Long-Run	Output Elasticity: Short-Run	Output Elasticity: Long-Run	Notes
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
1977	Fuss-Hyndman-Waverman	CS-TS: Canada, Provinces	1960-1971		-0.31	(positive)[1]		[1]Elasticity with respect to retail sales; statistically significant at better than 0.01 level.
1978	Lyman[2]	CS-TS: USA, Areas served by utilities for 10 regions	1961-1968		-3.64	---	1.00[3]	[2]Figures in Col. (4) pertain to regions. Elasticities are for the following areas: West Coast, Northwest Mid Northwest, Mid-west, Middle Atlantic Southwest, North Texas, South Texas, South, Florida and Gulf. [3]Number of customers. Constrained to unity by assumption. Elasticity with respect to income per house-hold not reported.
					-0.92			
					-1.33			
					-2.60			
					-1.15			
					-0.27			
					-4.56			
					-1.15			
					-0.75			
					-0.65			
Oct 1978	Chern-Just-Holcomb-Nguyen[4]	CS-TS: USA, states by census regions	1955-1974	-0.47	-1.31	0.25[5]	0.70[5]	[4]First row, New England; second row, Mid Atlantic; third row, East North Central; fourth row, West North Central; fifth row, South Atlantic; sixth row, East South Central; seventh row, West South Central; eighth row, Mountain; ninth row, Pacific. Results are for third stage least squares. [5]Real income per capita. [6]Population. [7]Number of customers. Note 6 and 7 not reviewed.
				-0.33	-0.51	1.22[5]	1.88[5]	
				-0.43	-1.60	0.20[5]	0.76[5]	
				-0.09	-1.02	NA	NA	
				-0.39	-1.27	0.33[5]	1.09[5]	
				-0.66	-1.29	0.33[5]	0.65[5]	
				-0.25	-1.60	0.03[5]	0.20[5]	
				-0.48	-0.90	NA	NA	
				-0.40	-0.66	0.31[5]	0.52[5]	
						0.18[6]	0.51[6]	
						0.51[6]	0.78[6]	
						0.08[6]	0.30[6]	
						0.02[7]	0.25[7]	
						0.10[6]	0.34[6]	
						0.20[7]	0.39[7]	
						0.03[6]	0.17[6]	
						0.54[7]	1.01[7]	
						0.78[7]	1.31[7]	

COMMERCIAL SECTOR PRICE AND OUTPUT ELASTICITIES

Date	Study	Data: Type	Data: Time Period	Price Elasticity: Short-Run	Price Elasticity: Long-Run	Output Elasticity: Short-Run	Output Elasticity: Long-Run	Notes
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
1980	Sahi-Erdmann	CS-TS: 7 Canadian regions	1963-1974	---	-1.388	---	---	
1980	Brendt-May-Watkins	TS: Alberta	1961-1976	-0.95/-0.84 [8]	---	---	---	[8] These elasticities refer to 1961 and 1976, respectively.
1980	Chern-Dick-Gallagher-Holcomb-Just-Nguyen	CS-TS: U.S. states	1955-1976	-0.294 [9] -0.208 -0.289 -0.172 -0.355 -0.589 -0.171 -0.438 -0.205	-1.508 -0.348 -1.410 -1.154 -1.176 -1.201 -1.425 -0.873 -0.366	---	---	[9] Rows are for New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain and Pacific States, respectively.
June 1982	Chern-Just-Chang	CS-TS: U.S. states	1955-1976	-0.58 [10]		0.94		[10] Mean of average price elasticities for the states.
?	Chung-Aigner	TS: 64 large customers of PGE	1975-1979	-0.079 [11]				[11] Non-weighted average of peak price elasticities.

Note: NA indicates not available, or not applicable.
TS indicates time-series data.
CS indicates cross-sectional data.
CS-TS: indicates pooled CS and TS data.

INDUSTRIAL SECTOR PRICE AND OUTPUT ELASTICITIES

Date	Study	Data		Price Elasticity		Output Elasticity		Notes
		Type	Time Period	Short-Run	Long-Run	Short-Run	Long-Run	
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
1977	Fuss-Hyndman-Waverman	CS-TS: Canada, 5 Regions	1961-1971		-0.74 [1]		--- [2]	[1] Mean value for Ontario 1961-1971 [2] Not reported. Electricity cost share declines as output increases indicating a value below 1.00.
1978	Lyman [3]	CS-TS: USA, Areas served by utilities for 10 regions	1961-1968		-0.86 -1.59 -2.31 -0.44 -1.64 -1.07 -3.52 -1.67 -2.58 -0.27	---	1.00 [4]	[3] Figures in Col. (4) pertain to regions including West Coast, Northwest, North Mid-west, Midwest, Middle Atlantic, Southwest, North Texas, South Texas, South, Florida and Gulf. [4] Number of customers. Constrained to unity by assumption. Elasticity with respect to income per household not reported.
Oct 1978	Chern-Just-Holcomb-Nguyen [5]	CS-TS: USA, Regions	1955-1974	-0.06 -0.02 -0.32 -0.26 -0.15 -0.28 -0.10 -0.19 -0.03	-0.16 -0.04 -0.54 -0.87 -0.71 -0.55 -0.62 -0.39 -0.09	0.50 1.01 0.74 0.25 0.21 0.48 0.17 0.38 0.32	1.14 1.55 1.28 0.83 1.03 0.96 1.03 0.80 0.90	[5] The first row of values is for New England; second row, Mid Atlantic; third row, East North Central; fourth row, West North Central; fifth row, South Atlantic; sixth row, East South Central; seventh row, West South Central; eighth row, Mountain; ninth row, Pacific. Results are for third stage least squares (3SLS).
1979	Pindyck [6]	CS-TS: 9 OCED Countries	1959-1974	---	-0.61 -0.63	---		[6] First row gives elasticities for Canada; second for U.S.

INDUSTRIAL SECTOR PRICE AND OUTPUT ELASTICITIES

Date	Study	Data: Type	Data: Time Period	Price Elasticity: Short-Run	Price Elasticity: Long-Run	Output Elasticity: Short-Run	Output Elasticity: Long-Run	Notes
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Aug 1979	Denny-Fuss-Waverman	CS-TS: 20 Canadian industries in 4 provinces	1962-1975	-0.531 [7]	-0.618 [7]	---	---	[7]Non-weighted averages for 20 industries.
May 1980	Chang-Chern [8]	TS: USA, 16 industries	1959-1976	-0.61	-1.14	0.40	0.76	[8]Elasticities are unweighted averages for 16 industries.
May 1980	Brendt-May-Watkins	TS: Alberta	1961-1976	-1.15/-1.04 [9]				[9]These elasticities refer to 1961 and 1976, respectively.
1980	Sahi-Dermann	CS-TS: 7 Canadian regions	1963-1974	---	-0.799			
1980	Chern-Dick-Gallagher-Holcomb-Just-Nguyen	CS-TS: U.S. states	1955-1976	-0.038[10] -0.081 -0.391 -0.172 -0.077 -0.298 -0.111 -0.201 -0.041	-0.114 -0.114 -0,594 -0.595 -0.433 -0.541 -0.481 -0.421 -0.104			[10]Data are for New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain and Pacific States, respectively.
May 1982	Dent-Kim-Chan-Felipe-Flynn-Ioannou	TS: For 11 Ontario industries	1975-1980	-0.203/-0.183[11] -0.213/-0.219 -0.185/-0.193	---	2.187/2.171	---	[11]Winter/summer noon hour price elasticities in 1975,1978, 1980, respectively, in each row.
1982	McRae-Webster	CS-TS:[12] Canada	1962-1976	-0.39[13] -0.26 0.00 -0.29 -0.32				[12]Results without pooling across regions were better. [13]Elasticities are for Atlantic, Quebec, Ontario, Prairies, and British Columbia, respectively.

INDUSTRIAL SECTOR PRICE AND OUTPUT ELASTICITIES

Date	Study	Data		Price Elasticity		Output Elasticity		Notes
		Type	Time Period	Short-Run	Long-Run	Short-Run	Long-Run	
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
June 1982	Chern-Just-Chang	CS-TS: U.S. states	1955-1976	-0.51[14] -0.85	-1.17[14] -1.92			[14]Average price elasticities for New York and Nevada, respectively. These span the range.
?	Chung-Aigner	TS: 64 large customers of PGE	1975-1979	-0.11[15]	---	---	---	[15]Non-weighted averages of peak price elasticities.

Note: TS indicates time-series data.
CS indicates cross-sectional data.
CS-TS indicates pooled CS-TS data.
Elasticities between short- and long-run columns are ambiguously defined in the reference cited.

BIBLIOGRAPHY

Acton, Jan Paul, Mitchell, Bridger and Sohlberg, Ragnhild, "Estimating Residential Electricity Demand under Declining Block Tariffs: An Econometric Study using Micro-Data," Applied Economics, Vol. 12, No. 2, June 1980, pp. 145-162.

Archibald, Robert B., Finifter, David H. and Moody, Jr., Carlisle E., "Seasonal Variation in Residential Electricity Demand: Evidence from Survey Data," Applied Economics, Vol. 14, 1982, pp. 167-181.

Battalio, Raymond C., Kagel, John H., Winkler, Robin C. and Winett, Richard A., "Residential Electricity Demand: An Experimental Study," December 1976.

Baughman, M.L. and Joskoy, P.L., "The Effects of Fuel Prices on Residential Appliance Choice in the United States," Land Economics, Vol. 51, No. 1, February 1975, pp. 41-49.

Besen, Stanley M., Kirby, Sheila Nataraj, Negri, Donald H. and Wetzel, Bruce, "Residential Demand for Energy: Some Preliminary Results," WD-1187-DOE, The Rand Corporation, August 1981.

Betancourt, Roger R., "An Econometric Analysis of Peak Electricity Demand in the Short Run," Energy Economics, Vol. 3, No. 1, January 1981, pp. 14-29.

Bohi, Douglas R., Analyzing Demand Behavior: A Study of Energy Elasticities, The John Hopkins University Press, Baltimore, 1981.

Chang, H.S. and Chern, W.S., "An Econometric Study of Electricity Demand by Manufacturing Industries," NUREG/CR-11358, Oak Ridge, Tennessee: Energy Division, Oak Ridge National Laboratory, May 1980.

Chern, Wen S., Gallagher, Colleen A., Tepel, Richard C. and Trimble, John L., "An Integrated System for Forecasting Electric Energy and Load for States and Utility Service Areas," NUREG/CR-2692, ORNL/TM-7947, Oak Ridge, Tennessee: Energy Division, Oak Ridge National Laboratory, May 1982.

__________, Just, Richard E. and Chang, Hui S., "A Varying Elasticity Model of Electricity Demand with Given Appliance Saturation," NUREG/CR-1956, ORNL/NUREG/TM-438, Oak Ridge, Tennessee: Energy Division, Oak Ridge National Laboratory, June 1982.

__________, Just, R.E., Holcomb, B.D. and Nguyen, H.D., "Regional Econometric Model for Forecasting Electricity Demand by Sector and by State," NUREG/CR-0250, ORNL/NUREG-49, Oak Ridge, Tennessee: Energy Division, Oak Ridge National Laboratory, October 1978.

Chung, Chinbang and Aigner, Dennis J., "Industrial and Commercial Demand for Electricity by Time-of-Day: A California Case Study."

Cocke, Marjorie R., Smith, Bruce A., Johnston, Tom L., and Howard, Robert T., "Determining Block Price Elasticities for a Lifeline Based Rate Structure," Minimax Research Corporation, Berkeley, California.

Cohn, S., Hirst, E. and Jackson, J., "Economic Analyses of Household Fuel Demands," ORNL/CON-7, Oak Ridge, Tennessee: Energy Division, Oak Ridge National Laboratory, March 1977.

Common, M.S., "Implied Elasticities in Some U.K. Energy Projections," Energy Economics, Vol. 3, No. 3, July 1981, pp. 153-158.

Denny, M.G.S., Fuss, M.A. and Waverman, L., "Energy and the Cost Structure of Canadian Manufacturing Industries," Technical Paper Series No. 12, Institute for Policy Analysis, University of Toronto, Toronto, Canada, August 1979.

Dent, D., Kim, S., Chan, K., Felipe, A., Flynn, B. and Ioannou, C., "Hourly Load Demand of the Ontario Industries: An Econometric Analysis," Economics Division, May 1, 1982.

Electric Power Research Institute, Long-Range Forecasting Prop rties of State-of-the-Art Models of Demand for Electric Energy, EPRI EA-221, Project 333, Vol. 1, December 1976.

Fuss, M.A., "The Demand of Energy in Canadian Manufacturing," Journal of Econometrics 5, Amsterdam: North Holland Publishing Company, 1977, pp. 89-116.

__________, Hyndman, R. and Waverman, L., "Residential, Commercial and Industrial Demand for the Energy in Canada: Projections to 1985 with Three Alternative Models," in W.D. Norhaus, editor, International Studies of the Demand for Energy, Amsterdam: North Holland Publishing Company, 1977, pp. 151-179.

Halvorsen, R., "Demand for Electric Energy in the United States," Southern Economic Journal, Vol. 42, No. 4, April 1976, pp. 610-625.

Hardman, Raymond S. and Werth, Alix, "Short-Run Residential Demand for Fuels: A Disaggregated Approach," Land Economics, Vol. 57, No. 2, May 1981, pp. 197-212.

Hirst, Eric and Goeltz, Richard, "Residential Energy Conservation Actions: Analysis of Disaggregate Data," Energy Systems and Policy, Vol. 6, No. 2, 1982, pp. 135-149.

Helliwell, John F. and Margolick, Michael, "The Link Between Electricity Prices and the Need for New Dams in British Columbia," Programme in Natural Resource Economics, Department of Economics, University of British Columbia, January 1982.

Houthakker, Hendrik S., "Electricity Demand Revisited," Discussion Paper Number 711, Harvard Institute of Economic Research, Harvard University, Cambridge, Massachusetts, June 1979.

________, Verleger, P.K., and Sheehan, D.P., "Dynamic Demand Analysis for Gasoline and Residential Electricity," American Journal of Agricultural Economics, Vol. 56, No. 2, May 1974, pp. 412-418.

Hyndman, R., and Mathewson, F., "A Model of Residential Energy Demand Estimated for Canada," Load Forecasting Discussion Paper 75-1, Ontario Hydro, May 1975.

Lillard, Lee and Acton, Jan Paul, "Seasonal Electricity Demand: A Variable Response Model," The Bell Journal of Economics, Vol. 12, No. 11, Spring 1981, pp. 71-82.

Lyman, R.A., "Price Elasticities in the Electric Power Industry," Energy Systems and Policy, Vol. 2, No. 4, 1978, pp. 381-406.

McRae, Robert N. and Webster, Alan R., "The Robustness of a Translog Model to Describe Regional Energy Demand by Canadian Manufacturing Industries," Resources and Energy 4, 1982, pp. 1-25.

Nemetz, Peter N., Hankey, Marilyn and Zethoff, Bert, "Economic Incentives for Energy Conservation at the Consumer Level in Canada (Year II Report)," April 1980.

Parhizgari, Ali M., and Davis, Penny S., "The Residential Demand for Electricity: A Variant Parameters Approach," Applied Economics, Vol. 10, 1978, pp. 331-340.

Pindyck, R.S., "The Structure of World Energy Demand," Cambridge, Massachusetts: The Massachusetts Institute of Technology Press, 1979, pp. 104-167.

________, "Interfuel Substitution and the Industrial Demand for Energy: An International Comparison," Review of Economics and Statistics, Vol. LXI, No. 2, 1978, pp. 169-179.

Roth, Timothy P., "Average and Marginal Price Changes and the Demand for Electricity: An Econometric Study," Applied Economics, Vol. 13, 1981, pp. 377-388.

Smith, V.D., "Estimating the Price Elasticity of U.S. Electricity Demand," Energy Economics, April 1980, pp. 81-85.

Spann, Robert M., and Beauvais, Edward C., "Econometric Estimation of Peak Electricity Demands," Journal of Econometrics, Vol. 9, 1979, pp. 119-136.

Taylor, L.D., "The Demand for Energy: A Survey of Price and Income Elasticities," in W.D. Norhaus, editor, International Studies of the Demand for Energy, Amsterdam: North Holland Publishing Co., 1977, pp. 3-43.

__________, Blattenberger, G.R. and Verleger, P.K., "The Residential Demand for Energy," EPRI EA-235, RP-431, Final Report, Vol. 1, Lexington, Massachusetts: Data Resources, Inc., January 1977.

Walker, James M., "The Residential Demand for Electricity: Further Empirical Evidence," Resources and Energy, Vol. 2, 1979, pp. 391-396.

Wilder, R.P. and Willenborg, J.F., "Residential Demand for Electricity: A Consumer Panel Approach," Southern Economic Journal, Vol. 42, No. 2, October 1975, pp. 212-217.

Wills, John, "Residential Demand for Electricity," Energy Economics, Vol. 3, No. 4, October 1981, pp. 249-255.

Wilson, J.W., "Residential Demand for Electricity," Quarterly Review of Economics and Business, Vol. 11, Spring 1971, pp. 7-22.

Yang, Yung Y., "Temporal Stability of Residential Electricity Demand in the United States," Southern Economic Journal, Vol. 45, No. 1, July 1978, pp. 107-115.

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